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Nanoconfinement of $LiBH_4$ for High Ionic Conductivity in Lithium Ion Batteries

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Efficient energy conversion and storage is crucial for development of systems based on renewable energy sources. For electricity storage, Li-ion batteries are commonly used in electronics devices but require many improvements to obtain longer life-time and higher energy densities. The current use of organic liquids and gels electrolytes limits these improvements because of lithium dendrites formation, reducing the lifetime of the battery and which can possibly be hazardous due to risks of short circuits.

An alternative to current state-of-art lithium-ion batteries could be solid-state batteries of higher stability and no risks of electrolyte leakage. $LiBH_4$ is a promising material for solid-state batteries as it is lightweight and stable electrochemically up to 5 V. Similar to other metal borohydrides, $LiBH_4$ exists in different polymorphs. While the orthorhombic phase(P*nma*), stable at room temperature has a low ionic conductivity (~10^{-5} mS cm^{-1} at 30 ˚C), the hexagonal phase (P*63/mmc*), stable above 110 ˚C, has a much higher ionic conductivity (~1 mS cm^{-1} at 120˚) [1]. Confinement of $LiBH_4$ in mesoporous SiO_2 allows obtaining fast ionic conductivity even at room temperature. Figure 1 shows Arrhenius plot of ionic conductivities of bulk $LiBH_4$ and nanoconfined SiO_2. For $LiBH_4$ the clear increase of the conductivity at 110 ˚C is due to the phase transition.

The origin of the high ionic conductivity in the nanoconfined $LiBH_4$ is due to an interfacial layer created between the borohydride and the walls of the SiO_2 pores. Better knowledge of the mechanisms behind the formation of this interface as well as the effect of the mesoporous SiO2 structure parameters (pore size, surface area,…) are crucial for improving even further the ionic conductivity of the low temperature solid electrolytes to be use in solid-sate lithium ion batteries.

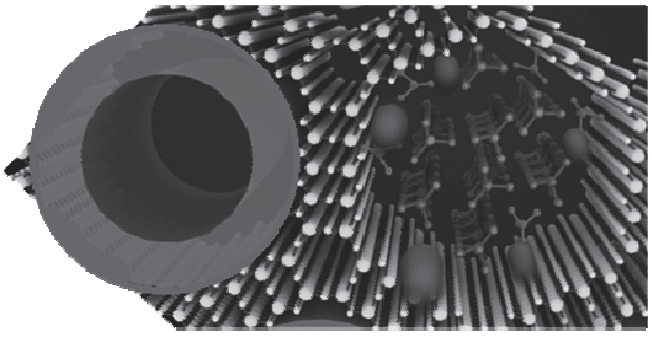

Figure 1. Nanoconfined $LiBH_4$ in SiO_2 scaffold [1]

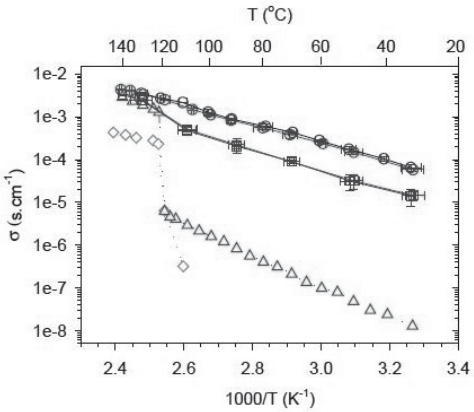

Figure 2. Arrhenius Plot of bulk $LiBH_4$ (red triangles), SiO_2 - $LiBH_4$ nanocomposites (circles and squares) and physical mixtures (green diamonds). Red symbols indicate measurements taken during heating and blue during cooling [1]

References

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